DOCUMENT RESUME

ED 475 712 TM 034 876

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TITLE Instructional Design Factors Prompting Reflective Thinking in Problem-Based Learning Environments: Comparing Middle School and College Students' Perceptions.

SPONS AGENCY National Aeronautics and Space Administration, Washington, DC.

PUB DATE 2003-04-00

NOTE 12p.; Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, April 21-25, 2003).

CONTRACT NCC5-432

PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)

EDRS PRICE EDRS Price MF01/PC01 Plus Postage.

DESCRIPTORS *College Students; Educational Environment; Higher Education; *Instructional Design; *Learning; *Middle School Students; Middle Schools; *Problem Based Learning; Scaffolding (Teaching Technique)

IDENTIFIERS *Reflective Thinking

ABSTRACT

Reflective thinking skills are important in a Problem-Based Learning (PBL) environment by helping learners engage deeply in the problem-solving process. The research on learners' perceptions of factors prompting reflective thinking in a PBL environment is limited, and it is not clear whether there is a difference in perceptions of these factors according to learners' developmental stages. This study investigated students' perceptions of design factors prompting reflective learning in a PBL environment in samples of 122 middle school students and 749 college students. Results indicate that both middle school and college students perceive two factors as helpful to their reflective thinking: learning environment and scaffolding tools. Middle school students perceived learning environment as the most helpful factor, while college students perceived scaffolding tools as most helpful. Differences in learners' perceptions were also found between the most helpful elements of the identified factors in each group. Suggestions are given for designing developmentally appropriate PBL learning environments that support reflective thinking based on these results. (Contains 3 tables and 23 references.) (Author/SLD)

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Instructional Design Factors Prompting Reflective Thinking in Problem-Based Learning Environments: Comparing Middle School and College Students' Perceptions

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This paper is prepared for the:
Annual Meeting of the American Educational Research Association
Chicago, IL - April 2003

Abstract

Reflective thinking skills are important in a Problem-Based Learning environment by helping learners to deeply engage in the problem-solving process. The literature suggests several key factors that prompt learners' reflection (task, instructional methods, learning environment, and scaffolding tools). However, the research on learners' perception of factors prompting reflective thinking in a PBL environment is limited. In addition, it is not clear whether there is a difference in perceptions of those factors according to learners' developmental stages. The results of this study indicated that both middle school students and college students perceived two factors as helpful to their reflective thinking: *learning environment* and *scaffolding tools*. Middle school students perceived *learning environment* as the most helpful factor whereas college students perceived *scaffolding tools*. Differences in learners' perception were also found between the most helpful elements of the identified factors of each group. Suggestions are given for designing developmentally appropriate PBL learning environments that support reflective thinking based on these results.

Instructional Design Factors Prompting Reflective Thinking in Problem-Based Learning Environments: Comparing Middle School and College Students' Perceptions

A problem-based learning (PBL) environment provides learners with an instructional mechanism that can increase their higher-order thinking skills while exploring authentic and ill-structured problems, participating in social interactions, and receiving coaching from peers and teachers (Albanese & Mitchell, 1993; Hmelo & Ferrari, 1997). However, PBL also brings cognitive challenges. For example, students must be challenged to clarify the causes of the problem, to decide important facts in problem situations, and to generate hypotheses for the solutions. To appropriately solve the problem in a PBL environment, it is important that students reflect on their understanding of an issue, new knowledge to develop a solution, and how their new knowledge can be used to address the situation. Reflecting on the problem helps learners to generate concepts and abstractions and enhance the transfer of learning to new problems (Barrow, 1998). If students lack these thinking skills, the PBL environment would be a chaotic rather than constructive in which they build their own meaningful knowledge. Thus, reflective thinking skills are needed to ensure a successful PBL implementation.

Key Factors that Prompt Reflective Thinking in a PBL Environment

Research suggests that various elements in the learning environment can prompt reflective thinking (Andrusyszyn & Daive, 1997; Griffith & Frieden, 2000; Lin, Hmelo, Kinzer, & Secules, 1999). Ill-structured, authentic, and complex tasks in a PBL environment, for instance are known to promote reflective thinking. These features of the task help students think reflectively because students have to investigate the problem in order to gather appropriate information to solve the problem (Stepien & Pyke, 1997). Another important element prompting reflective thinking is the

type of instructional method used. Virtanen et al. (1999) found that both an inquiry-oriented and an explanation-oriented instructional method were effective in a PBL environment. The inquiry-oriented method facilitates reflective thinking by asking reflective questions while the explanation-oriented method directs learners to reflect on important concepts (Moon, 1999; Virtanen et al, 1999). Creating flexible and active learning environments is also important in prompting reflective thinking during PBL. The elements that make the learning environment active and student-centered include allowing students to have enough wait-time to think before answering, providing a learner-controlled instruction, and promoting cooperative and collaborative learning (Michale & Susan, 1998; Rowe, 1974; Williams, 1996). Finally, scaffolding tools are important in prompting reflective thinking during PBL. Andrusyszyn & Daive (1997) and Kinchin & Hay (2000) reported on the effectiveness of reflective journal writing. Research also suggested that question prompts or concept maps could be used as aids to prompt reflective learning (Barrow, 1998; Griffith & Frieden, 2000; Kinchin & Hay, 2000). Therefore, key factors that encourage students to reflect upon their learning in a PBL environment seem to focus on the use of ill-structured and authentic tasks, the type of instructional methods, supportive and active learning environments, and scaffolding tools. However, it is not clear which factor(s) encourage students to engage in reflective thinking in PBL environments.

Learner's Perception of Factors Prompting Reflective Thinking in a PBL Environment

Although, it is widely believed that incorporating these factors in a PBL environment can support reflective thinking, little research has been conducted to investigate students' perceptions of these factors. While these key factors have been expected to increase the effectiveness of a PBL environment, students have not always perceived the use of these strategies as effective,

efficient, or attractive. The investigation of students' perception is critical because learners may or may not perceive designed factors as being helpful in prompting reflection (Koszalka, T., Song, H., & Grabowski, B, 2002; Wittrock, 1990). For example, students may not be aware of effectiveness of strategies used for the facilitation of reflective thinking. In addition, students may perceive the effectiveness of strategies derived from key factors prompting reflective thinking differently according to individual differences such as gender, home background, or age. In those cases, students' perceptions can affect their attitude toward strategies prompting reflective thinking, and it may eventually influence the effectiveness of PBL (Gallagher, 1994; Roeser, Eccles, & Sameroff, 2000). Thus, understanding students' perceptions of important environmental factors that help them reflect can inform the practice of developing a more efficient PBL environment.

The authors' initial study of factors prompting reflective thinking investigated the middle school students' perceptions in a general learning environment (Koszalka, T., Song, H., & Grabowski, B, 2002). Three factors perceived by students to affect that reflective thinking, found as a result of factor analysis, were instructional method, learning environment, and scaffolding tools. This finding suggests that students do not always think all factors are important in prompting reflective thinking, and their perceptions can be changed according to the characteristics of the learning environment. This study investigated which factors prompted reflective thinking in a PBL environment. The question was if students would perceive the same factors as important when they experienced them in a different learning environment, a PBL environment. Since the PBL environment has its own characteristics, students' perceptions of factors prompting reflective thinking may be different from the perceptions of other environments. However, no study has investigated students' perceptions of factors prompting

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reflective thinking in a PBL environment. We hypothesized that only certain factors would emerge as key factors prompting reflective thinking in a PBL environment.

A Developmental Difference in Learners' Perception of Factors Prompting Reflective Thinking

One difference to consider when examining learners' perception is their developmental level (Craig, 1983; Crain, 2000). According to King and Kitchener (1994), reflective thinking skill is the outcome of a developmental progression resulting from interaction between the individual's conceptual skills and environments that promote or inhibit these skills. They assume seven development stages of reflective thinking and mainly divided them into three sets in terms of developmental order: early stage referring pre-reflective thinking, middle stage occurring quasi- reflective thinking, and advanced stage occurring spontaneously reflective thinking. This suggests that individual ability to think reflectively is different according to his/her developmental stage. Middle school students are mostly in the pre-reflective thinking stage as they transit through many different developmental stages; while college students are in the middle or advance stages of reflective thinking. The authors' initial study has reported a significant difference in middle school students' perception of helpful elements prompting reflective thinking based on grade level. However, it is not clear how middle school and college students differently perceive the helpfulness of factors prompting reflective thinking.

Purpose of the Study

The primary focus of this study was to extend the authors' initial study by examining middle and college students' perceptions of the helpfulness of the factors designed to prompt reflective thinking in PBL environments. Differences in students' perception of factors prompting reflective thinking according to developmental stages were examined as well. The following research questions guided this study:

1. Which instructional design elements load together as factors that middle school students and college students perceive as helpful in prompting their reflective thinking in PBL environments?
2. Which of the identified factors was perceived as the most helpful in prompting their reflective thinking in PBL environments?
3. Which elements of all the factors were perceived as most helpful for prompting reflective thinking in PBL environments?
4. Are there differences in students' perception of the identified factors and elements in PBL environments based developmental stages?

Methods

Participants and Context

In this research, we report two related studies about students' perception of design factors prompting reflective thinking in a PBL environment: a study of middle school students' perception and a study of college students' perception.

To measure middle school students' perceptions, one hundred twenty-two middle school students, 70 boys, 51 girls, and 1 who did not identify their gender, from 3 public middle schools in a northeastern state participated in this study. These subjects came from intact groups in 6 different classrooms representing 6^{th} (n=83), 7^{th} (n=28), and 8^{th} (n=11) grades. To measure college students' perceptions, 749 college students attending 10 different sections of an Introductory Statistics course in a northeastern land-grant research university participated in the second study.

Measurement Instrument

A survey consisting of 10 carefully targeted questions for measuring the perceived

helpfulness of factors that prompt reflective thinking developed by the researchers was used (Koszalka, T., Song, H., & Grabowski, B, 2002). Each item of the survey queried students about one instructional design element predicted from the literature to prompt reflective thinking. The design elements included the ill-structured and authentic nature of tasks, explanation and questioning instructional methods employed by the teacher, supportive and flexible learning environment elements including collaborative learning, wait time, and learner control, and the use of scaffolding tools such as concept mapping, reflective writing, and reflective question prompts. Both middle school and college students were asked to respond to each question using a five-point Likert scale from strongly agree (5) to strongly disagree (1).

This survey was administered to middle school students (N=143) to measure their perceptions of factors prompting reflective thinking in science classroom environment (Koszalka, T., Song, H., & Grabowski, B, 2002). The Cronbach alpha reliability in the study was .890. The resulting Cronbach alpha reliability from data collected for middle school students in this study was .880 while the Cronbach alpha reliability for college students was .706

PBL Environments

Middle school and college students participated in different PBL environments. Middle school students participated in a PBL environment called Kids as Airborne Mission Scientists (KaAMS) designed and developed by the researchers to inspire students' interests in science, math, and geography. In this PBL environment, students were first presented with a problem situation to investigate--the active lava flows in Hawaii. To solve this problem, students needed to be able to a) identify the problem situation, b) propose ideas and search for information, c) collect and analyze data, and d) propose solution ideas. A variety of resources, which were mainly NASA web resources on both areas of aeronautics and remote sensing, were provided in

the program. Several reflection strategies were incorporated throughout the entire KaAMS PBL lesson plans to stimulate students to demonstrate reflective thinking actively and persistently. Both inquiry and explanation-oriented instruction methods were incorporated in the lesson plans for teachers. Various strategies facilitating active learning were also included. To support students' reflective thinking, a guided reflective workbook for students was provided. Students were encouraged to write reflectively or draw their own ideas on the journals driven by reflective question prompts. We observed that students experienced all these key factors supporting reflective thinking during their investigation.

College students participated in a statistics course designed to enhance problem solving ability based on the PBL principles. The PBL environment incorporated authentic and ill-structured problem situations, student-centered, teacher-facilitated activities, collaborative work, and guiding questions.

We acknowledge that a direct comparison between middle school students' perception and college students' perception has a limitation because they participated in different learning environments. However, both learning environments have a common characteristic that they were designed based on the essential design principles of PBL. We believe that the common characteristics of a PBL environment enable us to inquire about those factors that prompt each group's (middle and college students) thinking reflectively and descriptively compare them.

Procedure

Middle school students' perceptions were examined after completing the KaAMS PBL lessons. The average total amount of time for the completion of the KaAMS PBL lessons was 6 months. The student's exposure to the PBL environment during this amount of time ensured the stability of students' perceptions for factors prompting reflective thinking about a PBL

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environment. A survey was administered and collected by a classroom teacher at the end of these six months.

The college students' perceptions were examined after completing a fifteen-week course. The student's exposure to the PBL environment during this amount of time also ensured the stability of students' perceptions for factors prompting reflective thinking about a PBL environment. A survey was administered and collected by the instructor and teaching assistants at the end of the course.

Data Analyses

Maximum likelihood extraction and Varimax rotation methods were used to run a factor analysis to determine how the responses to the questions of instructional design elements loaded to the predicted factors. To test for differences among the factors, a paired sample T-test was conducted. An independent T-test was used to test for difference among the elements in the identified factors. All data analyses were conducted using the SPSS/PC+ statistical package (SPSS Window V. 10).

Results

Instructional Design Factors Prompting Reflective Thinking in PBL Environments

Four factors were predicted to emerge from the data: (1) instructional methods, (2) task, (3) learning environment, and (4) scaffolding tools. However, as shown in Table 1, in response to the first research question, *Which instructional design elements load together as factors that middle school students and college students perceive as helpful in prompting their reflective thinking in PBL environments?*; two factors emerged from the factor analysis using an Eigen value of 1.0.

The results from the study of middle school students' perception show that six items loaded to factor 1: authentic task, wait time, ill-structured task, inquiry-oriented instructional method, learner control, and collaborative learning. Four items loaded to factor 2: concept mapping, reflective writing, teacher explanation, and reflective question. The main characteristics of factor 1 appeared to relate to the *student-centered learning environment design* variable. The student-centered learning environment is defined by this data as being inquiry-oriented, collaborative, learner-controlled, flexible, and driven by authentic and ill-structured problem solving challenges. The questions that loaded to factor 2 appeared to relate to the *scaffolding tools* variable for prompting reflective thinking, as predicted. An unexpected result was that the question on 'teacher explanation' was loaded to the *scaffolding tools* factor. Instead of thinking about teacher explanation as an instructional method, students might consider it as a scaffold prompting their reflective thinking like other tools such as questioning, writing, or concept mapping.

The results from the study of college students' perceptions show that two latent factors were also identified based on an Eigenvalue of 1.0. Five items loaded to factor 1: learner control, wait-time before answering a question, authentic task, collaborative work, and concept mapping and five items loaded to factor 2: teacher question, ill-structured task, teacher explanation, reflective writing, and reflective question prompts. The main characteristics of factor 1 appeared to relate to the *student-centered learning environment* variable. The student-centered learning environment is defined by this data as being collaborative, learner-controlled, flexible, and driven by authentic problem solving challenges. The questions that loaded to factor 2 appeared to relate to the *scaffolding tools* variable for prompting reflective thinking using teacher question, teacher explanation, reflective writing, reflective questions, and ill-structured problem situations.

Table 1 Factor Loading of Elements That Prompt Reflective Thinking

Middle School Students				College Students			
Item	Item content	Factors 1	2	Item	Item content	Factors 1	2
2	Working on activities in class related to real problems on earth or in our society helps me think more about what I am studying.	.729	.118	7	Having freedom in class to explore topics I am interested in helps me think more about what I am studying.	.629	.135
6	Having time to think about a question before answering helps me think more about what I am studying.	.691	.244	6	Having time to think about a question before answering helps me think more about what I am studying.	.497	.107
1	Working on activities in class that have many different answers helps me think more about what I am studying.	.664	.331	2	Working on activities in class related to real problems on earth or in our society helps me think more about what I am studying.	.391	.273
4	When my teacher asks me how to solve difficult tasks it helps me think more about what I am studying.	.594	.426	5	Working with partners during classroom activities helps me think more about what I am studying.	.335	.202
7	Having freedom in class to explore topics I am interested in helps me think more about what I am studying.	.510	.309	8	Drawing pictures to illustrate my understanding of a topic helps me think more about what I am studying.	.328	.322
5	Working with partners during classroom activities helps me think more about what I am studying.	.498	.191	4	When my teacher asks me how to solve difficult tasks it helps me think more about what I am studying.	2.380 E-02	.570
8	Drawing pictures to illustrate my understanding of a topic helps me think more about what I am studying.	.132	.742	1	Working on activities in class that have many different answers helps me think more about what I am studying.	.273	.445
9	Writing about my understanding of a topic helps me think more about what I am studying.	.284	.736	3	When my teacher explains how to solve difficult tasks it helps me think more about what I am studying.	.189	.440
3	When my teacher explains how to solve difficult tasks it helps me think more about what I am studying.	.509	.609	9	Writing about my understanding of a topic helps me think more about what I am studying.	.244	.401
10	Answering questions about a topic helps me think more about what I am studying.	.484	.560	10	Answering questions about a topic helps me think more about what I am studying.	.231	.313

Students Perceptions of Factors Prompting Reflective Thinking in PBL Environments

In response to the second research question, *Which of the identified factors was perceived as the*

most helpful in prompting their reflective thinking in PBL environments? middle school and college students perceived these differently.

The results from the study of middle school students' perceptions demonstrated that factor 1- student-centered learning environment emerged as the highest ranked factor (M = 3.79, SD = .74), followed by factor 2- scaffolding tools (M= 3.37, SD = .91). Table 2 indicates that there was a significant difference between these two factors. These results suggested that students perceived the student-centered learning environment as the most significant factor in prompting their reflective thinking.

However, the results from the study of college students' perceptions showed that that factor 2- scaffolding tools emerged as the highest ranked factor (M = 2.23, SD = .63), followed by factor 1- learning environment (M= 2.02, SD = .59). Table 2 also indicates that there was a significant difference between these two factors. These results suggested that college students perceived the scaffold tools as the most helpful factor in prompting their reflective thinking.

Table 2 Paired Samples T-Test for Factors

Middle School Students						College Students					
Factors	**M**	**sd**	**T**	**df**	***P***	**Factors**	**M**	**sd**	**T**	**df**	***p***
F1 Learning Environment	3.79	.74	6.39	114	.01	F1 Learning Environment	2.02	.59	-9.1	748	.00
F2 Scaffolding Tools	3.37	.91				F2Scaffolding Tools	2.23	.63			

Students' Perception of Instructional Design Elements Prompting Reflective Thinking in PBL Environments

Meanwhile, in response to the research question, *Which elements of all the factors were perceived as most helpful for prompting reflective thinking in PBL environments?*, middle school

and college students perceived these differently as well.

The results from the study of middle school students' perceptions showed that the highest ranked elements were both loaded to the student-centered learning environment factor and were of a social and learner control nature. See Table 3. The mean scores for item 5 –working with partners (M = 4.06, SD = 1.16) and item 7 –having freedom to explore topics (M = 4.02, SD =.99) were statistically the same, but significantly higher mean scores than all other items.

Table 3 Means and Standard Deviations of Question Items

Middle School Students				College Students			
Factor	**Item**	**M**	**SD**	**Factor**	**Item**	**M**	**SD**
F1 Learning Environment	**5.Working with partners during classroom activities helps me think more**	**4.06 A**	1.16	F2 Tools	**4. When my teacher asks me how to solve difficult tasks it helps me think more**	**2.39 A**	1.013
F1 Learning Environment	**7.Having freedom in class to explore topics I am interested in helps me think more**	**4.02 A**	.99	F2 Tools	**1. Working on activities in class that have many different answers helps me think more**	**2.39 A**	1.08
F1 Learning Environment	5. Having time to think about a question before answering helps me think more.	3.82	.97	F2 Tools	**9. Writing about my understanding of a topic helps me think more**	**2.38 A**	1.08
F1 Learning Environment	1. Working on activities in class that have many different answers helps me think more	3.82	.92	F2 Tools	10. Answering questions about a topic helps me think more	2.01	.92
F1 Learning Environment	2. Working on activities in class related to real problems on earth or in our society helps me think more	3.68	.99	F2 Tools	3. When my teacher explains how to solve difficult tasks it helps me think more	1.98	1.01
F1 Learning Environment	4. When my teacher asks me how to solve difficult tasks it helps me think more	3.35	1.04	F1 Learning Environment	5.Working with partners during classroom activities helps me think more	2.16	1.11
F2 Tools	3. When my teacher explains how to solve difficult tasks it helps me think more	3.75	.99	F1 Learning Environment	8. Drawing pictures to illustrate my understanding of a topic helps me think more	2.10	1.06
F2 Tools	8. Drawing pictures to illustrate my understanding of a topic helps me think more	3.39	1.22	F1 Learning Environment	7.Having freedom in class to explore topics I am interested in helps me think more	2.06	.99

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F2 Tools	10. Answering questions about a topic helps me think more	3.32	1.08	F1 Learning Environment	2. Working on activities in class related to real problems on earth or in our society helps me think more	1.98	.79
F2 Tools	9. Writing about my understanding of a topic helps me think more	3.03	1.20	F1 Learning Environment	6. Having time to think about a question before answering helps me think more.	1.79	.82

Note: [A] Statistically the same, statistically different from all other mean scores at the .05 level.

The results from the study of college students' perceptions showed that the most highly ranked elements were loaded to the scaffolding tool factor and were 'teacher question' (M=2.39, SD= 1.01) and 'ill-structured task' (M= 2.38, SD=1.08), followed by 'reflective writing' (M=2.38, SD=1.08). The mean scores for those three items were statistically the same, but significantly higher than the mean scores of all other items.

Discussion

The primary research questions in this study was to identify and compare instructional design factors and elements that the middle school and the college students perceived as helpful in prompting their reflective thinking in PBL environments.

Two Factors Prompting Reflective Thinking in a PBL environment

Whereas the literatures report several key factors that prompt reflective thinking, two factors were found as a result of factor analysis for both middle school and college students in these two studies. Both middle school and college students perceived the student-centered learning environment and the scaffolding tools as factors prompting reflective thinking in a PBL environment. However, two other factors (instructional method, task) were not found as major factors in this study.

This also differs from the result in the early study by Koszalka, Song, & Grabowski (2002) in a general science-learning environment in which three factors emerged. The instructional method factor reported in authors' initial study was not found in this study and two elements in

this factor (*teacher question* and *teacher explanation*) were loaded to either the student-centered learning environment factor or the scaffolding tools factor in the middle school students group and loaded together to the scaffolding tool factor in the college students group. It is interesting that *the teacher explanation* loaded to the scaffolding factor in the both groups but *the teacher question* loaded to the scaffolding tool factor in the only college students groups. This suggests that both students perceived *the teacher explanation* as a scaffolding tool helping them to solve the problem in a PBL environment. However, middle school students perceived the teacher question as a characteristic of leaning environment rather than a scaffold tool.

Two elements in a task factor, *ill-structured and authentic task* characteristics were also not emerged as a factor in both groups. One possible reason why the task factor was not emerged and combined with the other factors can be found in the characteristics of a PBL environment. PBL researchers report that authentic and ill-defined tasks are especially an important characteristic of a PBL environment (Albanese & Mitchel, 1993; Barrow, 1998). Therefore, students might not separate the task factor from the other factors such as the learning environment or the tool factor.

Most Helpful Factor

While middle school students perceived the student-centered learning environment as the most helpful factor, college students perceived the scaffolding tool as the most helpful. Researchers on PBL have reported that student-centered nature of learning is the most essential characteristic of the PBL environment (Barrow, 1988). In fact, PBL emphasizes the self-directed learning in which students take a responsibility for their learning. The elements in the student-centered learning environment factor are all related to make learning independent and active.

Most Helpful Elements

The most important elements in the middle school students were collaboration and

having freedom in the classroom, generally classified in the literature as the social and learner control nature of the learning environment. These two elements are essential in making PBL student-centered. Two major learning approaches in PBL are self-directed learning characterized by learner control and a small group learning emphasized as social learning. On the contrary, the most important elements in the college students were teacher question, ill-structured task, and reflective writing. These elements are essential tools in making students self-directed leaner in PBL environments.

While middle school students perceived the elements in student-centered learning environment factor that support their learning as the most helpful, college students perceived elements in the scaffolding tool that promote self-directed learning as the most helpful. These findings imply that middle school students prefer a learning climate in which they can interact with their classmates in prompting their reflective thinking whereas college students prefer a scaffold to help them to be self-directed learners such as teacher questions, reflective writing, or ill-structured task.

Differences in Helpfulness by Developmental Stages

Differences in perceptions were found in terms of factor and elements that prompt reflective thinking based on developmental stage. The result that middle school students perceived the students-learning environment factor as more helpful than college students reveals that students in a pre-reflective thinking stage can benefit more from creating supportive experiential environments than students in middle or advance stage of reflective thinking stage in PBL environments. The result that college students, on the other hand, perceived the scaffolding tools as most helpful implies that they can benefit more from supporting self-directed learning in PBL environments. In fact, this implication was supported from the result in that college students

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perceived the reflective writing as one of the most helpful elements whereas middle school students less helpful. These findings support the importance of developmentally appropriate instruction. According to National Middle School Association (1995), young adolescents who are in between the ages of 10 to 15 are in a transition period from concrete thinking to abstract thinking. Since the participants in the study 1 were from 6th graders to 8th graders, we assume that they are in the stage of concrete thinking, and thus they need more interesting and experiential learning rather than reflective writing. These findings imply that we must consider individual differences when we support reflective thinking in PBL environments.

Conclusion

This study explored the question of what factors in a PBL environment could prompt reflective thinking considering students' developmental stages. We examined both middle school and college students' perceptions of factors prompting reflective thinking after implementing PBL lessons. The findings indicate that both students perceived Student-Centered Learning Environment and Scaffolding Factor as helpful factors prompting their reflective thinking. However, they perceive differently the helpfulness of the identified factors and the elements in those factors. This implies that we must consider the characteristics of developmental stages when designing a PBL environment supporting reflective thinking.

The findings of this study have important implications for supporting reflective thinking in a PBL environment by empirically identifying design factors learners perceived as most helpful prompting their reflective thinking. One of the most meaningful finding in this study was the importance of the student-centered learning environment and scaffolding tool. Given that both factors include various design elements, it is important to further refine and test the attributes of each factor. Since the characteristics of a PBL learning environment overlap with those of a

constructivist learning environment, future study may investigate various design strategies to identify the attributes of the student-centered learning environment and scaffolding tools for prompting reflective thinking in a PBL environment.

Further research is also needed to investigate the relationship between the student-centered learning environment factor and the scaffolding tools factor. Recently, many scaffolding tools using current technology are devised to help students' higher order thinking skills in a PBL environment. The elements in the student-centered learning environment factor in this study can be used for major design strategies for developing scaffolding tools.

Acknowledgement: This project was made possible through funding from the National Aeronautics Space Administration, Leading Educators to Applications, Research, and NASA-Related Educational Resources in Science (LEARNERS), a Cooperative Agreement Notice from the NASA Education Division and Learning Technologies Project. Project Number: NCC5-432: Learning Using ERAST Aircraft for Understanding Remote Sensing, Atmospheric Sampling and Aircraft Technologies, (LUAU II).

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